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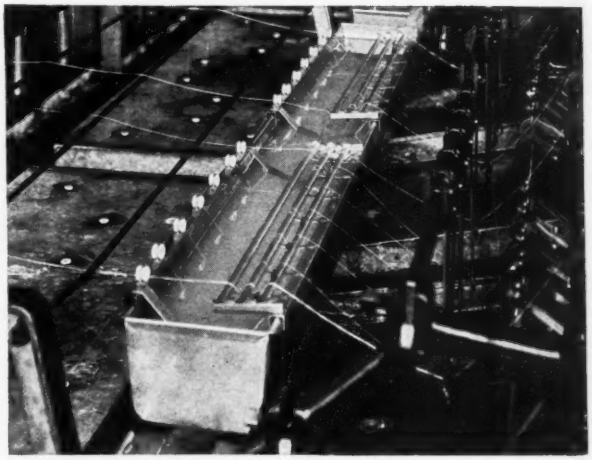

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AUGUST 21, 1939

VOLUME 28 NUMBER 17

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VOLUME 28 AUGUST 21, 1939 NUMBER 17

The Physics of Color Tolerance

DEANE B. JUDD*

ABSTRACT

The physical specification of a reflecting sample requisite to determine its color is the spectrophotometric curve. The spectrophotometer not only gives more complete and fundamental information about such a sample than can be determined by direct visual inspection, but also is generally more sensitive than the human eye, and the results are reproducible. There are, however, pairs of samples which have the same daylight colors which do not have the same spectrophotometric curves. It is, therefore, necessary to take into account some of the properties of the human visual mechanism evaluated by psychophysical methods. These properties are expressed in the response curves of the eye defining the groups of physically dissimilar lights which look alike to the average normal observer. By using these response curves, together with the spectral energy distribution of an illuminant and the spectrophotometric curve of the sample, it is possible to calculate a color specification for the sample. A standard coordinate system for colorimetry has been adopted by an international standardizing body. Graphical, arithmetical, mechanical, and electrical shortcuts have been devised for the reduction of time taken up by the computations. The color specification most commonly takes the form of daylight apparent reflectance, *A*, of the sample and two trichromatic coefficients, *x* and *y*, which indicate chromaticity, apparent reflectance and chromaticity indices taken together make up the color specification. Color differences are evaluated by differences in *A*, *x*, and *y*. A physical quantity can only be defined in terms of the operations which have to be carried out to evaluate it. The above-mentioned operations which lead to differences in *A*, *x*, and *y* are, therefore, the definition of what is meant physically by color difference; this is an unambiguous definition, and by it the color difference between any two samples may be unambiguously evaluated. However, these evaluations often do not agree with estimates of the color differences obtained by direct visual inspection of the samples. Many attempts have been made to devise a series of operations to serve as an alternate definition of color which would yield this agreement, but none of the suggested methods has yet been generally accepted. There is some prospect that a system analogous to the present standard coordinate system will be devised within a few years to give color spacing in accord with perception. The chief obstacle is the paucity of information on the perceptibility of color differences. This information has to be evaluated by psychophysical methods. The physicist awaits the completion of this information with interest because of its bearing on color tolerance, but in the meantime finds many color tolerance problems in which questions of perceptibility are overshadowed by questions of permanence of materials and possible degree of manufacturing control. To these latter questions the present coordinate system is perfectly applicable.

BY the physics of color tolerance, one perhaps ought to mean the "pure" physics of it; but it has been found impossible to confine these remarks to pure physics. Attention to other aspects of color tolerance have, however, been reduced to a minimum.

These remarks take the form of a dialogue in two scenes between Mr. Dyer, who dyes fabrics for automobile upholstery, and Mr. Meter, the "pure" physicist. Any resemblance of these characters to real persons, living or dead, is purely coincidental.**

Scene 1, Mr. Meter's Office

Enter Mr. Dyer.

Dyer: Mr. Meter, my firm dyes fabrics for upholstery, mostly for automobiles. The pieces are cut out according to pattern and sewn together. Now if the pieces are all cut out of the same run, they would stand some chance of matching when sewn together and there wouldn't be so much trouble. But our customers produce on a farily large scale; they cut up all the cloth of each large roll into pieces of the same pattern. These pieces are then sewed to those cut from other rolls of goods often from other mills. Sometimes all of the rolls are closely of the same color, but mostly there are differences between rolls which we cannot avoid; so when two pieces are sewed together, the customer is likely to object. It would save us a lot of money if we could tell ahead of time which pieces will match closely enough to be acceptable to the customer. The way it works now, the upholstery has to undergo a whole series of color inspections before it gets to the automobile buyer. The automobile manufacturer is more particular than the ultimate consumer, the upholstery manufacturer is more particular than the automobile manufacturer, and our inspector is still more particular; that's the way it has to be not to have a hitch anywhere along the line. But if we went at this thing scientifically, maybe we could satisfy the ultimate consumer without having to be about four times as particular as he is to provide several margins of safety along the line. This would save everybody a lot of money. So we have decided to measure some samples of our colors, and I was referred to you, Mr. Meter, for advice. They told me that you have an instrument called a color analyzer or spectrophotometer or some such thing that will measure color.

Meter: Yes, we can measure your samples on the spectrophotometer; we can give you a curve analyzing the light reflected by the sample by showing just how much of it falls in the red part of the spectrum, how much in the

*Physicist, National Bureau of Standards; Chairman, Committee on Color Problems, Inter-Society Color Council.

**In the presentation of this dialogue as an Introduction to the Technical Session of the Inter-Society Color Council, February 23, 1939, Dr. Judd read the part of Mr. Meter. The part of Mr. Dyer was read by Dr. I. H. Godlove, Technical Laboratory, Dyestuffs Division of the Du Pont Company.—EDITOR.

orange, yellow, and so on. Two samples having the same curves have the same color.

Dyer: I'll have to look into these technical details later; but here are my samples, all of them reddish shades of sand brown. I can see the difference between these two all right, but several of these pairs might have been cut from the same roll of cloth as far as I can tell. They were picked out by one of our inspectors, and he is really particular; sometimes I wonder if he can actually see these differences, or is just guessing. But generally one inspector will reject about the same goods as another. Here, what do *you* think about it? I suppose with a trained eye like yours—

Meter: I'm afraid my judgment would be of little use to you; I am accustomed to using the spectrophotometer for the detection of color differences. We find that visual estimation just results in argument and difference of opinion. You are lucky with your somewhat old-fashioned methods (you will pardon the frankness of science, Mr. Dyer) not to have more trouble than you do. The spectrophotometer is more sensitive than the human eye[1] and the results are reproducible.[2] We don't really have to look at samples at all. If we wanted a color match we could run a spectrophotometric curve of the sample, then send the curve to a dyer using our methods, and they could send back the match without having seen the original sample at all.

Dyer: That certainly takes out the human element. If you get two identical curves, you have a color match; and if you get different curves, you have different colors.

Meter: Well, there is more to it than that, Mr. Dyer; as you probably know, you can sometimes get samples that will color match in daylight but fail to do so in lamp light. Such pairs of samples have different spectrophotometric curves.[3]

Dyer: I am getting a little mixed up here. If you get the same spectrophotometric curves, you know you have the same colors, but if you get different curves sometimes you *still* have the same colors?

Meter: Without getting too technical, Mr. Dyer, the whole thing comes down to this. The spectrophotometric curve defines the reflecting properties of the sample, but to deduce the appearance of the sample from its reflecting properties requires some further information. The first additional item is the spectral character of the light source and the angle at which the light is incident upon the sample. Specification of the light source is pure physics and can be accomplished in a definite and satisfactory way.

Dyer: It looks rather involved to me. Do you use light hitting the sample from one direction only?

Meter: Sometimes illumination at 45° is used, and sometimes completely diffused illumination; that is, light striking the sample equally from all directions.

Dyer: I doubt if either one of those kinds of lighting would give us information comparable to what we get from our inspectors. They look at the sample from many angles, and hold it up sometimes so that the light strikes it at a glancing angle, and then again with the light more or less perpendicular to the sample.

Meter: I don't deny that there are difficulties about modes of illumination and viewing; but if you will use *our* methods I am sure you will get along much easier. At least you will know exactly what condition of lighting *was* used. This is specified definitely by physical methods. But to get back to the second item of information required. The appearance of the sample also depends upon what person looks at it; that is, a color-blind person, as you know, does not see these samples the way you and I do. The way we handle this question is to use a standard observer representative of average, normal vision, determined by "psychophysical methods." Of course, the research necessary to evaluate this observer, the psychophysical research, involves something other than pure physics; and we physicists were somewhat reluctant to use the results. But, as you know, color has to do with seeing, so there is no other way out; and I must say that the psychophysicist has done a pretty good job on the standard observer. You would hardly know it isn't physics. This standard observer has been adopted by the International Commission on Illumination[4]; it is used by the National Bureau of Standards, by Massachusetts Institute of Technology, and by many industrial organizations.

Dyer: I am not sure I understand just how I could use this standard observer.

Meter: By using the standard observer we get a color specification from the spectrophotometric curve; it's just a matter of computation.

Dyer: You mean after you get the curve you still have computations to make?

Meter: Yes, there is a regular standardized way of computing the color from the spectrophotometric curve.

Dyer: This is harder than I thought.

Meter: Oh, it's not so bad. We have short cuts of various kinds that reduce the computations for a sample to a matter of minutes.[5]

Dyer: And what do you have when you get through with these computations?

Meter: You have a fundamental color specification according to a method that is coming to be universally recognized.

Dyer: And if I have a sample specified by this method, do I know for sure that another sample with the same specification will match it?

Meter: Positively, — er, unless your observer has abnormal color vision, or unless the illuminant is different from what was put into the computations. This method gives you three numbers for each sample; and if two samples have the same triad of numbers, they have the same color, — subject, of course, to the limitations I just mentioned.

Dyer: What do you call these numbers?

Meter: Well, first, you get the daylight apparent reflectance of the sample; this is high for light samples and low for dark; so it is a specification of the lightness of the color. Then you get two values, x and y, which indi-

cate chromaticity; the indices of lightness and chromaticity, taken together, form a complete specification of the color.

Dyer: Well, Mr. Meter, it's all Greek to me, but I'll take your word for it. Could you tell from all your curves and computations which of my samples is the closest match to the standard, which the next best, and so on?

Meter: Well, no. The psychophysical information required to give the answer to *that* question was never put into the standard observer and coordinate system; so you cannot hope to get it out. As a matter of fact, that information has never been completely worked out.

Dyer: Oh! (disappointed) Then I'm afraid all this curve drawing and computation won't be of so much use to me. If we are to satisfy our customers, we *have* to make judgments of best match all the time. We get our inspectors to do it. I was hoping you could tell us how to do it better.

Meter: The great trouble with your present use of the method of direct estimate is that you have no record of the judgments; whenever similar samples come to hand again, you have to get your inspector to make another guess.

Dyer: Yes, that is true; I begin to see what you mean.

Meter: I suggest that you express all of your samples, standards and rejected samples, in terms of x and y and daylight apparent reflectance, A. Then you will know definitely what the acceptable shades are. And another thing, — there will be many cases when the spectrophotometric curve alone will tell you all you want to know; in fact, that will be true in a majority of cases. If you are working with samples all from the same dye bath, and have records of the limit samples, you can tell at a glance directly from the curve of a new sample whether the customer is going to object.

Dyer: Yes, I see how that might work out.

Meter: But that's not the half of it. Not only will the spectrophotometer assist in establishing, specifying and administering color tolerances, but it will also make possible control of your dyeing process so you won't have any rejections. *You* thought you might reduce expenses by taking full advantage of the customer's tolerance to color difference. I will show you how to reduce your losses from rejections of off-color deliveries to a minimum. I am fairly familiar with the problem of dyeing to a standard sand brown. The trouble comes mainly because the dye bath has to contain at least three dyes. These dyes go onto the fabric at different rates; so after a while the balance of the mixture is significantly disturbed and the fabric comes out off-color. What you have to do is follow the rate of exhaustion of the dyes from the dye bath by means of the spectrophotometer. In this way you will know exactly what color the fabric will be.

Dyer: Well, maybe it's worth a trial. How much does a spectrophotometer cost? One that is accurate enough to pick up these small differences, and fast enough to give us results in time to be of value. Oh yes, — and foolproof enough to keep going under plant conditions.

Meter: I can see that you require an automatic, recording spectrophotometer. And I am sure that you will find it important enough to require the services of a trained operator; these are precision built instruments that cannot be made foolproof.

Dyer: Well, I guess it's worth a trial. Send one up, and recommend somebody to run it. How much will it cost?

Meter: Five thousand dollars. Is that too steep?

Dyer: (earnestly and with great emphasis) My dear Mr. Meter, to a concern doing millions of dollars worth of business, with products sold in every state in this glorious land of ours and exported to all the principal countries of the world, and with payrolls of thousands of workmen in several states, five thousand dollars is but a trifle. (Aside, nervously) I hope it does some good.

Exit Dyer.

End of Scene 1

Scene 2, Six Months Later, Same Place

Enter Dyer.

Meter: Glad you dropped in again, Mr. Dyer. How is the new spectrophotometer working?

Dyer: Doing very nicely, thank you. All you hear around the mill now is "Send it up to the 'spectro' and see who is right." You see we soon got tired of calling it the automatic, recording, photoelectric spectrophotometer; so we call it the 'spectro' for short. It certainly helps out in our sales; the buyer takes one look at the spectro drawing its own curve and forgets to argue about color tolerance. We have a slogan, "With scientific color control, you *know* it's right."

Meter: I hope I didn't encourage you to buy a spectrophotometer just for sales promotion.

Dyer: Far from it. Although I can't say our troubles with color tolerance are over, the spectro has already saved us a lot of money. The other day we dyed fifty rolls of goods to the same color simultaneously in fifty different dye pots and they were accepted without question. We speeded up production and still had no rejections. A few months ago we would have said that was impossible, and without rigid control of the concentration of dyes in the bath it would be impossible today; furthermore, we are only just beginning to learn how to apply the instrument to our problems.

Meter: I am not surprised at your report, but, of course, I am gratified at your success. The methods I recommended to you are past the experimental stage; they have been verified time and again.

Dyer: I hope you won't think I am complaining when I return to you with the same problem I had originally. Although it is not as urgent now as I used to think it was, we still would like to be able to tell more certainly which of two samples is the better match, and to tell ahead of time from our measurements whether the customer is going to object. Taking time for a customer survey is a rather expensive method. We have tried out a few cases to see whether the tolerances in terms of A, x and y,

which we derived from a customer survey on sand brown would apply to other colors.

Meter: I believe I warned you that this information could not be gotten from our present standard method.

Dyer: I know you did; but I thought maybe we could get approximate information that would be of some value. You were right, though; we found it necessray to set considerably different tolerances depending upon the particular color we were working with. Isn't there some automatic way to relate differences in A, x, and y with size of color difference?

Meter: I do not, myself, know how to construct a physical scale giving uniform spacing of color sensation; it's rather out of my line. There have been proposed some methods for that purpose[7], but none of them has so far been generally adopted; and, I understand, work is still going on directed to that end. I have had such good success, however, with the spectrophotometer alone, and with colorimetric specifications according to the standard system that I have not bothered to try these new methods out very thoroughly. When the psychophysicist has really done a thorough job of it, I won't have to worry about the validity of the method myself. When I see evidence that truly reliable results can be obtained, *then* I am willing to consider other methods to substitute for the standard methods[8].

Dyer: Well, I see that the business of physicists is to make measurements, and I suppose it is the business of psychologists to study the behavior of people. You've helped me a lot to control and measure my fabrics, but if I want to know the effect of these fabrics on my customers (and I certainly do) maybe I ought to consult a psychologist.

Meter: Confidentially, I don't advise it. No psychologist I ever met could talk your language; at least they didn't talk mine. The only kind of quantities that I have found worth talking about are those resulting from physical measurement. A physical quantity is uniquely defined in terms of the operations which have to be carried out to evaluate it[6]. The specification of color difference which I recommended falls almost perfectly under this definition of a physical quantity. I say *almost* perfectly because, as I mentioned before, the standard observer has been determined by methods not strictly physical. But once the observer is adopted arbitrarily, there is no ambiguity about the specification of color in terms of A, x and y; so in this sense they are physical specifications. Psychologists don't deal with any such quantities; they talk about such things as the attributes of color being hue, tint and chroma; but I haven't found out yet how to get a numerical evaluation of any of them.

Dyer: Well, how about consulting one of these psychophysicists, then?

Meter: *That* might not be so bad; and I wouldn't mind coming with you. Maybe a psychophysicist can tell me what a hue difference is in terms that really mean something.

(Exit Meter and Dyer together.)

Acknowledgments

It is a pleasure to acknowledge the assistance of Drs. I. H. Godlove and A. W. Kenney of the du Pont Company, of Drs. L. A. Jones and D. L. MacAdam of Eastman Kodak Company, and of Prof. A. C. Hardy of Massachusetts Institute of Technology, in the preparation of this dialogue.

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PROGRAM

Nineteenth Annual Meeting

Copley-Plaza Hotel, Boston, Mass., September 15 and 16

FRIDAY, SEPTEMBER 15

9:00 A.M. Registration Opens in Lobby of Copley-Plaza Hotel.

9:30 A.M. One Hundred and Twenty-fourth Council Meeting.

11:00 A.M. One Hundred and Seventeenth Meeting of the Research Committee.

12:30 P.M. Luncheon for Council and Research Committee.

2:00 P.M. Bridge Tournament for Visiting Ladies.

2:00 P.M. First Technical Session in Grand Ballroom.

"The Dyeing of Nylon—A Preliminary Survey" by PHILIP H. STOTT of *E. I. duPont deNemours & Co.*

2:25 P.M. "Progress in Research from the Consumer Point of View" by DR. PAULINE BEERY MACK of *Pennsylvania State College.*

2:55 P.M. "Identification of the Newer Textile Fibers" by JOHN H. SKINKLE of the *Lowell Textile Institute.*

3:15 P.M. "Semi-Resin Finishes for Cotton Piece Goods" by W. W. TROWELL of the *Hercules Powder Co.*

3:40 P.M. "Flexibility and Drape as Measurable Properties of Fabric" by L. J. WINN, A.A.T.C.C. Research Assistant, and DR. EDWARD R. SCHWARZ of the *Massachusetts Institute of Technology.*

4:15 P.M. "Tintinoil Process" by EDWARD H. SCHMIDT of the *Borne Scrymser Co.*

4:35 P.M. "A New Type Water Repellent" by GEORGE A. SLOWINSKE of *E. I. duPont deNemours & Co.*

5:00 P.M. "Textone—A New Oxidizing Agent for the Treatment of Textiles" by G. P. VINCENT, A. L. DUBEAU and J. D. MACMAHON of *Mathieson Alkali Works.*

6:30 P.M. Buffet Supper for Members and Visiting Ladies in Grand Ballroom.

8:00 P.M. Official Welcome to the Convention and ANNUAL BUSINESS MEETING. Entertainment.

SATURDAY, SEPTEMBER 16

9:30 A.M. "Microscopic Observations of Wool Dyeing" by H. E. MILLSON, G. L. ROYER and G. E. WISSFMANN of the *Calco Chemical Co.*

9:55 A.M. "A Motion Picture Study of Some Dyeing Phenomena" by R. H. KIENLE and G. L. ROYER of the *Calco Chemical Co.*

10:10 A.M. "Sodium Sulfate Error in Measuring the Acid Content of Carbonizing Baths" by H. C. OLSEN and W. B. PRESCOTT with DR. H. C. CHAPIN of the *Lowell Textile Institute.*

10:20 A.M. "New Concepts in the Chemistry of Wool" by DR. MILTON HARRIS, Director of Research for the *Textile Research Associateship at the National Bureau of Standards.*

11:00 A.M. "The Present Status of Casein Fiber" by E. O. WHITTIER and S. P. GOULD of the *Bureau of Dairy Industry.*

11:25 A.M. "Surface Cation Active Compounds in the Textile Industry" by JACOB KATZ of the *Warwick Chemical Co.*

11:45 A.M. "The Development of Methods for the Determination of the Causes of Damage Appearing in Wool after Dyeing" by BERTIL A. RYBERG, Research Associate of the *A.A.T.C.C. supported by the Textile Foundation at the Lowell Textile Institute.*

12:10 to 12:30 P.M. "Modern Dyeing of Staple and Spun Viscose Rayon" by CHARLES B. ORDWAY of *American Aniline Products.*

12:45 P.M. Luncheon for National and Sectional Officers Only.

Afternoon. Sightseeing Trips.

7:00 P.M. BANQUET, Grand Ballroom (*Dress Optional*). (Ladies may sit in the balcony for program.)

Abstracts

of Papers to be Presented at Nineteenth Annual Meeting

Surface Cation Active Compounds in the Textile Industry

JACOB KATZ
Warwick Chemical Co.

WITHIN the last few years a new series of organic derivatives have appeared in the textile industry under the name of "Cation Active Compounds." They are called "cation active" because the interesting (effective) part of the molecular structure is the cation (positively-charged part of the molecule), whereas most of the surface active substances employed in the textile industry today are anionic (negatively charged) in activity. Inasmuch as the cation compounds are diametrically opposed to soaps, sulfated alcohols, etc., in ionic structure, so the chemical and physical reactions are opposed to each other. Many of these organic cation compounds are immune to hard water, acids, bases, and salts. They are compatible with starches, gums, dextrines, etc., and are substantive to cellulosic materials. At present they are being used for:

1. Stripping vat and azoic dyeings.
2. Permanent finishing.
3. Auxiliaries.

Chemically these cationic compounds are organic derivatives of nitrogen bases. The system is based on nitrogen with a valence of three and five. The many compounds may be classified into three main divisions.

1. The acylated nitrogen bases and pyridine compounds.
2. The salts of pyridine, alkyl amines, etc.
3. The quarternary ammonium salts.

Identification of the Newer Textile Fibers

JOHN H. SKINKLE
Asst. Prof. of Textile Chemistry, Department of Chemistry and Dyeing, Lowell Textile Institute

FROM the standpoint of identification, the newer fibers are markedly difficult to identify because some are microscopically like certain of the older fibers, some give chemical reactions like some of the natural fibers, and some give none of the present reactions of the common fibers but require new tests of their own. The newer fibers include glass fibers, condensed amines and acids (Nylon), vinyl resin fibers, casein wool, mixtures of viscose and casein. Whereas the older fibers could be separated into groups by chemical tests but ultimate detection required the microscope, the newer fibers cannot be identified immediately by the microscope but require confirmatory chemical tests. This paper will describe the tests which are required and the microscopical appearances of the new fibers in contrast to the chemical reactions and microscopical appearances of the older fibers.

Tintinoil Process — A New Method for the Tinting and Conditioning of Textile Fibers

EDWARD H. SCHMIDT
Borne Scrymser Co.

THE constantly increasing use of various types of rayon, as is, and in admixture with cotton, wool, cellulose acetate and silk has made imperative some simple means to permit rapid identification of the stocks in the mill.

Heretofore, the only means of tinting the cut rayon stock or other textile fiber was to dye it in a regular dyeing machine. After dyeing, the staple is hydro-extracted and then dried. After drying, the dyed stock is blended with undyed stock in the picker. This dyeing, extracting and drying leaves the fiber in a harsh, wiry condition, greatly impairing its spinning properties.

Further, many cotton mills which have gone over to rayon or other synthetic fibers are not equipped with dyeing machines. Therefore, use of the conventional method of tinting would require a substantial expenditure for equipment.

The Tintinoil Process consists of a mechanical unit which can be attached to any mixing or blending hopper—at no cost to the mill. The unit is set up for one or more colors. The Tintinoils are contained in reservoirs of suitable capacity, each piped to the metering unit. Any color can be had by the turn of a valve. The process is convenient, automatic and economical.

The Tintinoil Process, fully covered by patents, eliminates the necessity for a separate dyeing operation and the subsequent hydro-extracting, drying and blending.

Tintinoil, which contains conditioning agents, is available in all colors, made from certified dyes which are fugitive when applied to all natural and synthetic fibers.

Modern Dyeing of Staple and Spun Viscose Rayon

C. B. ORDWAY
Technical Dept., American Aniline Products, Inc.

A DISCUSSION of dyeing methods used in the past on cotton and how they have been applied on staple and spun viscose rayons. The physical and dyeing properties encountered in the processing of staple and spun viscose rayons.

Dyestuff manufacturers have realized that viscose rayon in the staple and spun forms is a distinct fiber or fabric and must be so treated, and dyed. Factors involved in the simplification of dyeing methods for these distinct fibers and fabrics covers:—

1—Dyestuffs and chemical costs;

2—Dyeing methods as to labor and time costs;

3—The effect of dyeing method on processed goods in subsequent manufacturing operations or on finished fabrics;

4—The dyeing method's chemical reactions, if any, and how they may affect the materials composing the dyeing equipment;

5—Fastness results obtainable on dyed goods.

The growing importance of the application of Formanil colors to staple and spun viscose rayons is due largely to the simplicity and economy of these directly dyed and formaldehyde aftertreated colors.

On staple and spun viscose rayons, the Formanils offer better wash, light, and perspiration fastness than that obtainable on cotton.

Spun viscose rayon yarns or fabrics containing wool, rabbit hair, acetate, or silk may be dyed in union shades or effect color combinations by this dyeing method without injury to the fibers other than viscose rayon.

Formanil colors meet many of the requirements presented for the obtaining of satisfactory and simplified dyeing of colors on staple and spun viscose rayons for raw stock, warp, yarns, and piece goods.

Semi-Resin Finishes for Cotton Piece Goods

W. W. TROWELL
Hercules Powder Co.

SYNTHETIC resins have been used for some time for certain selected applications of textile finishing. Only recently, however, have synthetics been combined with orthodox finishing ingredients to obtain semi-resin finishes.

This development has been accomplished by the introduction of a new type of thermoplastic resin which shows exceptional compatibility with starches, softeners, mineral oil, waxes, gums, gelatin, latex, sulfonated oils, and other materials commonly used in finishing.

The excellent stability of emulsions of these resins, both alone and in combination with the above mentioned ingredients, makes it possible to produce a wide variety of semi-resin finishes showing marked utility in the finishing of cotton piece goods.

A description of the handling of such resins in back-filling and pure finishing, together with attendant advantages and limitations, is presented. Also cited is the fact that these advantages can be obtained without an increase in overall finishing costs.

A Motion Picture Study of Some Dyeing Phenomena

(Kodachrome Motion Picture)

R. H. KIENLE and G. L. ROYER
The Calco Chemical Company, Inc.

THE paper will be presented as a motion picture taken in color by the Kodachrome process. Practically all of the views have been taken through the microscope and show action taking place in color as would be seen by actual microscopic examination of the phenomena which are shown. The moving picture makes it possible to show to a large group phenomena which previously have been observed by only a few.

Chemical reactions which produce actual dyestuff are carried out under the microscope and one can see the dye being formed from the intermediates.

The dyeing of wool will be shown in such a manner that one can actually see the dyeing of individual fibers. Several types of dyes will be contrasted in their dyeing characteristics.

A similar dyeing procedure carried out under the microscope shows the dyeing of casein wool with the same dyestuffs and demonstrates definite differences from the dyeing of wool.

Both casein wool and natural wool will be shown decomposing in concentrated sulfuric acid and this will indicate certain differences in properties due to the internal structure of the two fibers.

The dyeing of a blend of various fibers with a dye mixture containing dyes which are substantive to only a certain type of fiber will demonstrate the use of such a dye mixture for fiber identification.

These motion picture studies show the dyer what the microscope can reveal about many of the phenomena which are well known to him. It gives an insight into these phenomena which has proved interesting and instructive.

Microscopic Observations of Wool Dyeing

H. E. Millson, G. L. Royer and M. E. Wissemann
Calco Chemical Company, Inc.

THE recent literature shows considerable interest in the dyeing of wool. Much theoretical discussion has been written on the subject. It is not the idea of this paper to enter into this discussion but rather show some observations which have been made while making microscopic examinations on certain wool dyeing problems. In this study it has been observed how the individual wool hairs react and how they are responsible for many of the phenomena which are seen in the dyehouse.

By the use of cross-sections prepared by the Hardy method, it can be observed how the dyes enter into the hairs. Reactions carried out on the individual fibers under the microscope also reveal interesting structural differences which have their effects upon dyeing.

Fluorescent light will be used as an interesting tool to show differences between the penetration of fluorescent dyes and will be used to explain certain dyeing characteristics of wool.

Cross-sections of many types and sizes of dyed and undyed wool will be shown by Kodachrome color slides. The progress of dyeing wool with several kinds of dye will be shown by cross-sections made at definite time intervals. Commercial dyeings on new stock, dyeings on previously dyed stock, and dyeings made by varying the order of adding the color will demonstrate what happens in the individual wool hairs.

The fact that wool is a mixture of hairs having quite widely different dyeing characteristics will be shown. Tippy dyeing will be illustrated and data will be presented suggesting exposure of the wool to light as one cause of this phenomenon. Microscopic slides in color will demonstrate how dyes react to these exposed and unexposed hairs.

The use of the microscope in the identification of wool and its related fibers will be demonstrated by both characteristic dye reactions and physical forms as shown in colored photomicrographs.

Flexibility and Drape as Measurable Properties of Fabric

L. J. Winn* and E. R. Schwarz**

FOLLOWING a survey of the literature (See American Dyestuff Reporter, March 20, 1939, and *Textile Research*, April, 1939) the initial portion of the experimental program undertaken at the Massachusetts Institute of Technology Textile Research Laboratories under the direction of the A.A.T.C.C. Committee on the Evaluation of Permanent Finishes in Textiles has been concerned with the measurement of flexibility and drape on a series of instruments devised for this purpose and on a series of ten fabrics ranging from a heavy, resin treated, stiff cotton material through tracing cloth, organdie, cotton and rayon fabrics of various weights to a soft, napped pile fabric similar in appearance and handle to an inexpensive velvet.

The instruments employed were the hanging loop technique for determining the bending length of the specimen, the Gurley flexibility tester adapted to use for textiles, the Schiefer flexometer, and the Bellinson drape tester.

As a result of the determinations of bending length, flexural rigidity, bending modulus, flexing force, drape length, chord length and radius of curvature the series of fabrics have been graded in order of their apparent flexibility. Using as a basis the rigidity of the fabric which is essentially a measure of stiffness, the Spearman coefficient of rating has been computed together with its standard deviation for all samples and under various conditions of test. A correlation table indicates excellent agreement as to rating between the bending length, the rigidity and the measurements performed on the drape tester and the Schiefer flexometer. Less perfect correlation exists between the other methods of test and the order of the fabrics as to stiffness indicated by means of the measurements of rigidity.

In general the data shows that rather inexpensive and easily operated apparatus is satisfactory for the measurement of fabrics of the character of those tested and it is

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**Professor of Textile Technology, in charge of Textile Division, M.I.T., Cambridge, Massachusetts.

hoped later to correlate this information with actual physical and psychological tests.

The nature of the apparatus employed is discussed together with certain of the advantages and disadvantages inherent to the operation of the various machines. Further details of technique on methods which are relatively new in this country at least are outlined and a simple drape test is described.

The Present Status of Casein Fiber

E. O. Whittier and S. P. Gould

Division of Dairy Research Laboratories, Bureau of Dairy Industry, U. S. Department of Agriculture

CASEIN fiber was manufactured for the first time on a commercial scale in Italy in 1936. Production in Europe is now at the rate of about 10 million pounds a year. The chief producer is the Snia Viscosa of Milan, Italy, which uses the process of Ferretti.

In the United States, the only patents on casein fiber so far issued are the public service patents of Whittier and Gould. The fiber is not yet being produced commercially in this country, although several rayon firms have done some development work and one large dairy organization is planning to begin production in the near future in Rhode Island. The process to be used there differs from the processes previously mentioned.

In all the processes so far disclosed, casein is dissolved in alkali and the solution extruded through spinnerettes into an acid bath, usually containing formaldehydes. Various modifiers are used in the casein solution and in the precipitating bath and the fibers are usually aftertreated with formaldehyde solutions, salt solutions, and textile oils.

The Ferretti process requires a casein that has been exposed to an acidity of pH 2.9, the Whittier and Gould process uses any good commercial acid-precipitated casein, and the process to be used in Rhode Island uses a casein especially prepared.

Casein fiber resembles wool both chemically and physically. Its chief faults have been its inferior tensile strength and its tenderness when wet. Both of these faults are being gradually overcome. It is produced as staple fiber and has been woven almost entirely in mixture with wool. More recently, fabrics have appeared in which casein fiber has been woven with viscose rayon and with cotton. Some fiber has been produced from mixed solutions of casein and viscose.

The Dyeing of Nylon
A Preliminary Survey

P. H. Stott

Technical Laboratory, Dyestuffs Division E. I. du Pont de Nemours & Co., Inc.

THIS paper is intended to summarize experimental work done to date on the dyeing of Nylon to ascertain the most suitable colors evaluated from the standpoint of applicability and certain fastness properties. Much of the data presented will be in the form of lists of dyestuffs identified by name and Colour Index number showing the affinity of these dyestuffs for Nylon and their adaptability for the fiber in various forms. The paper will include discussions on the most suitable dyestuffs found so far for the dyeing of hosiery and yarn based on semi-practical trials and will indicate possibilities of cross-dye effects between Nylon and other textile fibers.

New Concepts in the Chemistry of Wool

Dr. Milton Harris

Director of Research for the Textile Research Associateship at the National Bureau of Standards

SOME new concepts based on the research program of the Textile Foundation at the National Bureau of Standards are presented.

A New Type Water Repellent

George A. Slowinske

E. I. du Pont de Nemours & Co.

A DISCUSSION will be given of a new type of water repellent which combines with textiles to form a water repellent complex. The new agent is a single chemical compound, and is distinct in character from older type products.

Sodium Sulfate Error in Measuring the Acid Content of Carbonizing Baths

H. C. Olsen and W. B. Prescott with Dr. H. C. Chapin

Lowell Textile Institute

IN solutions around 4 per cent sulfuric acid, sodium sulfate additions caused error in specific gravity measurements amounting to 1.28 times the percent of sulfate present. Electrical conductances were affected by sodium sulfate in the opposite direction, but less than one-fifth as much.

CORRECTION

Re: Wetting Agents

In the paper "A Consideration of the A.A.T.C.&C. Official and Canvas Disc Methods for the Evaluation of Wetting Agents" by Carl Z. Draves which appears in the issue of August 7th, on page P422 the Gooch funnel is erroneously referred to as "a good funnel."

Transportation and Sightseeing

YOUR Transportation and Sight-Seeing Committee presents rail and airplane rates between Boston and distant points. A few examples of the low rates for both train and airplane transportation are as follows:

Train Fares*

From Boston to	*One-Way First Class Rail Fare*	*Rail Fare Round Trip 30-60 Day Limit First Class*	*One-Way Pullman Lower Berth Rate*
New York, N. Y.....	$6.90	$10.35	$2.65
Philadelphia, Pa.	10.50	21.00	2.65
Cincinnati, Ohio	28.05	50.50	6.30
Chicago, Ill.	30.55	55.00	7.10
Cleveland, Ohio	20.40	37.85	4.50
Detroit, Mich.	23.30	42.75	5.25
Atlanta, Ga.	32.81	59.65	8.70
Greenville, S. C.	28.81	51.95	7.35
Charlotte, N. C.	25.91	46.65	6.85
Nashville, Tenn.	34.52	61.85	8.95
Winston-Salem, N. C..	23.97	43.40	6.60
Columbus, Ga.	37.20	64.95	9.20

There is a slight reduction on both the rail fare, as well as the Pullman rate for upper berths.

Airplane Service

Inasmuch as Boston has so much in the way of points of historic and cultural interest there are many who will want to stay over until Sunday. Due to the excellent airplane schedules to the South and the West it will be possible to spend the better part of Sunday in and around Boston, leaving on an afternoon plane and arriving at most distant points the same night.

A few examples of the low airplane rates are as follows:

From Boston to	*Fare*
Washington	$24.15
Richmond	30.05
Greensboro, N. C.	41.50
Charlotte	46.05
Greenville, S. C.	51.45
Atlanta	60.10
Knoxville, Tenn.	52.10
Chicago	54.20
Milwaukee	59.20
Cincinnati	49.00
Cleveland	37.85
Buffalo	28.21
Pittsburgh	32.95

*Railroad patrons should get off at Back Bay Station. (Huntington Avenue from the west.) Two-minute walk to the hotel.

Round trip fares between Boston and the above points are double the above figures less 10 per cent.

If you have any sudden change in your plans late Saturday there will be representatives from both the railway and airplane lines to take care of you.

The airport is only 15 minutes by taxi from the hotel.

Sight-Seeing

When you attend the convention you naturally will want to take in historic points of interest in and around Boston. Among the many interesting sight-seeing tours that will be available we particularly recommend to you one of the following:

Tour No. 1—ANCIENT and MODERN BOSTON including Bunker Hill Monument, Charlestown Navy Yard, Water Front, Fish Pier, Army Base, Old North Church, etc.
Time—Approximately 2 hours.
Special rate—$1.00 per person.

Tour No. 2—PICTURESQUE BOSTON, BROOKLINE AND CAMBRIDGE TOUR including Christian Science Church and Mapparium, Residential Boston, Brookline, Harvard Buildings, Collection of Glass Flowers at the Agassiz Museum, Longfellow's Home, etc.
Time—Approximately 1¾ hours.
Special rate—$1.00 per person.
Combination of these two tours may be had for $1.50 per person.

Tour No. 3—LEXINGTON AND CONCORD covering all points of interest described in Tour No. 2 continuing along over the famous Ride of Paul Revere to Monroe Tavern, Lexington, Hancock Clarke House, Old North Bridge, Louisa May Alcott's House, Hawthorne's Wayside, etc.
Time—Approximately 4 hours.
Special rate—$1.50 per person.

When you register we suggest making known your intentions to the Sight-Seeing Committee or the representative of the sight-seeing company who will be on hand.

Annual Meeting and Convention

September 15 and 16, Boston, Mass.

Chemistry and Cancer Genesis*

With Some Reference to Lubricants, Chemicals and Dyes Employed in the Textile and Other Industries

M. J. SHEAR**

THERE is an imposing list of industries in which the workmen have a higher incidence of cancer than other individuals of the same age in the general population. The first of the occupational cancers to be described was cancer of the scrotum which occurred in a large number of chimney sweeps in the 18th century.

Murphy (1939) has recently listed the industries in which occupational cancers have occurred, and the agents responsible for the genesis of the tumors. This list, somewhat modified, is as follows:

Occupation	*Agent* (Proven or Suspect)
radium and X-ray workers	rays of short wave-length
chimney sweeps	soot
cobalt smelters	arsenic
cobalt miners	unknown
aniline dye workers	aromatic amines
watch dial painters	radium or mesothorium
farmers, sailors, etc.	sunlight
coal tar distillers	tar, paraffin
paraffin workers	shale oil
cotton mule spinners	lubricating oil

The word "cancer" denotes growths which are termed "malignant" because they continue to grow without restraint, invade and destroy neighboring healthy tissue, and ultimately result in the death of the host. Not infrequently, they "metastasize," i.e., fragments of the original tumor get carried to some other part of the body and set up secondary malignant growths in new locations. "Tumor" is a more inclusive term than cancer, and denotes all growths, including benign as well as malignant ones. "Carcinogenic" means cancer-producing.

The reasons for believing that certain occupations are responsible for the production of certain types of cancers accumulated slowly over a long period of time. A number of observers had noted that some types of cancer occurred much more frequently in workmen in certain industries than in men employed in other occupations. In England, for example, "The unusual incidence of cancer amongst mule-spinners began to be noticed about 1908, and again was brought under prominent notice by the work of two Manchester surgeons just after the war. Serious concern was caused in the cotton industry. This led the Home Office to appoint a special committee of investigation in 1925; the committee reported in 1926. In their report they confirmed the view that mineral oil was the cause of this special form of cancer and collected from the Registrar-General's returns data to show that the death rate from this cancer in cotton operatives, as compared to a mean national death rate of 4 per million living males, was 134 in cotton spinners and 72 in cotton workers undefined. These figures do not, of course, refer to cancer generally but only to this particular form of cancer."†

The existence of this type of occupational cancer is confirmed by the agreement in the findings of numerous investigations. Not all, however, agree that the lubricating oil is the chief villain in the piece. For example, Robertson (1927) attributed the tumor formation in the scrotum to constant irritation of the scrotum by the coarse overalls worn, and to the blue aniline dye used in the overalls, since examination of the men showed that they are stained around the scrotum and down the legs with blue dye. Somerford (1935), impressed by the large numbers of patients with cancer of the face in an English hospital which serves a large and extensive industrial area, particularly the cotton textile industry, considered that some other factor in addition to the oil might be necessary for cancer production. He suggested that perhaps the heat of the spinning room (80° to 100° F.) may be of some significance; in addition, there is no doubt a certain quantity of oil particles suspended in the atmosphere at these temperatures, he stated.

In refutation, Irvine (1935) cited his own study of the occurrence of cancer of the skin in males in the Blackburn Registration District of England for the years from 1837 to 1929. His figures showed that cancer occurred much more often in the cotton mule-spinners than in any other group. This was true regardless of the part of the body in which the cancers occurred, but was particularly true of cancer of the scrotum. In 1921, for example, non-scrotal cancers were 4 times as common in cotton mule-spinners as in other textile workers or in employees in

*Presented at meeting, Northern New England Section, Feb. 17, 1939.

**Office of Cancer Investigations, U. S. Public Health Service, Gibbs Memorial Laboratory, Harvard University, Cambridge, Mass.

†From the Report of the Manchester [England] Committee on Cancer, 1932-33 and 34.

other industries; scrotal cancers were 35 times as common. Irvine considered it highly improbable that friction alone, in the absence of exposure to mineral oil, would cause scrotal cancer in spinners; certainly the disease occurred in these workers before the introduction of colored and stiffened overalls. He concluded that exposure to mineral oil is the main factor in the initiation of skin cancer in such workers, although some other factor such as continued friction, injury, a burn, or local anatomic peculiarities, might play a part in determining the site of the growth or in hastening its appearance.

Much of our knowledge regarding the role of mineral oils in cancer is due to C. C. Twort and his coworkers, who have been studying this problem experimentally for many years. They found that "some mineral oils are very much more carcinogenic than others, but that all of them, other than white oils (such as medicinal liquid paraffin, etc., and the lighter boiling spirits) have to be viewed as potentially carcinogenic. We next endeavoured to group the oils according to the degree of carcinogenicity and it was found that the textile oils were, on the whole, the most carcinogenic, being considerably more so, for instance, than the relatively heavier grade internal-combustion engine oils."*

Chemical and physical studies of many types of mineral oils were carried out in Twort's laboratory, and the cancer-producing potency of the materials was tested experimentally by applying them repeatedly to the skin of mice. In 1929 Twort and Fulton reported that the cancer-producing activity of the oils was much reduced or completely destroyed by extraction with sulfuric acid, by oxidation, and by reduction. A combination of methyl sulfate and picric acid was found particularly valuable for removing carcinogenic agents from oils. Since methyl sulfate is known to remove benzenoid hydrocarbons quantitatively from light spirit, and since treatment with sulfuric acid, which destroys the carcinogenic activity of the oils, also destroys the fluorescence which is a phenomenon connected with the presence of the benzene ring, Twort and Fulton (1929) concluded that their work "supports the view that benzenoid hydrocarbons are responsible for the carcinogenic properties."

Heller (1930) reviewed the chemical properties of tar, pitch and mineral oil handled in industries in the United States with a view to correlating them with the incidence of cancer in the workmen engaged in those industries. Among his conclusions were the statements that mineral oils vary in carcinogenic activity according to their unsaturated hydrocarbon content, and that cancer is not attributable to the occupation of mule-spinners in the United States possibly because of the carefully refined lubricating oils used on the machines, thus ensuring relative freedom from unsaturated hydrocarbons.

Twort* tested in mice the carcinogenic properties of mineral oils obtained from various parts of the world. While mineral oils obtained from the United States were found to be less active than oils from Roumania, Persia, Borneo, Venezuela and from Scotch Shale, the oils of this country were by no means inactive. For example, the Pennsylvania oils tested had more carcinogenic activity than the Russian oils, while the California oils were 4 times as active as the Pennsylvania oils in producing tumors.

The unravelling of the facts underlying the clinical observations has been possible because of the information provided by researches with experimental animals. When it became evident many years ago that there was something in tars and oils which produced cancer in man, attempts were made to produce cancer experimentally in laboratory animals. These attempts ended in failure until 1915, when two Japanese investigators, Yamagiwa and Ichikawa, reported that they had succeeded in producing cancer of the skin of rabbits by frequent painting of the skin with tar for long periods of time.

This at once opened up the field for systematic investigation. Their finding was confirmed, and then extended, in many laboratories all over the world. (For details, see review by Woglom, 1926). One of the outstanding questions was the nature of the compound, or compounds, present in tars and oils that was responsible for the production of cancer.

Without going into the details of the history of this aspect of the subject, it was finally discovered in 1933 by a group of workers in London, under the direction of E. L. Kennaway, that carcinogenic coal tar contained a very small amount of a strongly fluorescent, yellow hydrocarbon, which was a powerful carcinogen. To this compound, hitherto unknown, was given the name 3,4-benzpyrene (see Fig. 1).

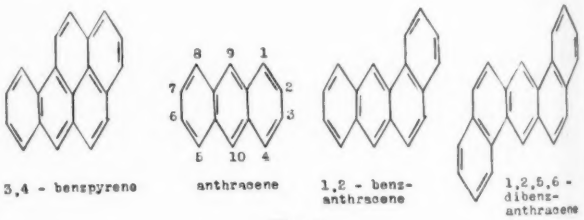


Fig. 1

This was not, however, the first chemical compound found to be carcinogenic. During the many years that the hunt for the active substance in coal tar was going on, the London investigators tested the action of a large number of compounds which contained condensed aromatic ring systems, i.e., a number of benzene rings attached together as, for instance, in anthracene or phenanthrene.

In the course of this systematic research, Kennaway and Hieger discovered in 1930 the first instance of a pure chemical having the power to produce cancerous growths. This compound was 1,2,5,6-dibenzanthracene, i.e., a deriv-

*See footnote† page 451.

ative of anthracene having a benzene ring attached at the 1,2-positions, and another ring at the 5,6-positions (see Fig. 1).

The London workers found that this substance would not only produce skin cancer when applied to the skin, but that it would also produce cancer of the deeper tissues when injected underneath the skin.

They thereupon synthesized a large series of related compounds and tested their action in animals in an attempt to ascertain which structural features of the molecule were responsible for conferring the power to incite malignant growths. A considerable number of these newly-synthesized compounds were found to be carcinogenic. Moreover the potency varied from compound to compound, depending upon the variations made in their molecular structure.

While this work was going on in the cancer field, other workers were studying the chemistry of substances present in the bile, which is a liquid produced in the liver and collected in the gall bladder. In the course of this work, they produced a compound, methylcholanthrene, whose structure is shown in Fig. 2. The London workers, seeing the resemblance in its structure to compounds which they had already found to be carcinogenic, tested it in mice and rats and found it to produce cancer in a remarkably short time. In our laboratory cancer has been produced with this compound in mice in a month and a half.

In 1932 we began investigations in this field in the United States Public Health Service in its laboratories at Harvard. After confirming the findings of the London group, and after extending the work in several directions, the Service, in 1934, invited Professor Fieser of the Division of Chemistry of Harvard University to join us in a collaborative investigation in this field.

Professor Fieser and his co-workers have, since then, synthesized a large number of compounds which have been examined for their cancer-producing behavior in the laboratories of the Service at Harvard. In addition to the testing of these and other compounds to ascertain which are cancer-producing, various types of researches on the genesis of cancer by chemical compounds have been carried out by the members of the staff of the cancer research laboratories of the Service.

As far as the results correlating structure and potency are concerned, the results (Shear, 1938, 1939) may be briefly summarized as follows:

When the molecules of dibenzanthracene, benzpyrene, and methylcholanthrene were changed in the direction of greater complexity, the power to produce cancer was usually greatly diminished or completely abolished. However, when the structures were modified in the direction of greater simplicity, it was found that several of them still possessed marked carcinogenic activity.

With this type of compound, therefore, the essential features of molecular structure required to produce carcinogenic potency appear, on the basis of evidence at present available, to be a 4 ring system condensed as in 1,2-benzanthracene, containing simple substituents at appropriate positions. Some of the simpler 4-ring derivatives found to be quite potent are shown in Fig. 2. A number

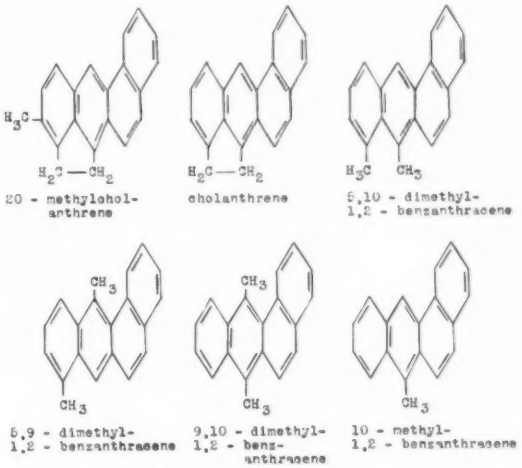

20 - methylcholanthrene
cholanthrene
5,10 - dimethyl-1,2 - benzanthracene
5,9 - dimethyl-1,2 - benzanthracene
9,10 - dimethyl-1,2 - benzanthracene
10 - methyl-1,2 - benzanthracene

Fig. 2

of the interesting new compounds have been synthesized by Dr. M. S. Newman and his co-workers, in the Department of Chemistry of The Ohio State University, who have been collaborating with the Public Health Service for several years. At the present time work is progressing in the laboratories of the Service to ascertain whether these structures may be simplified still further without loss of potency.

In addition to producing cancer of the skin and of the connective tissue and muscle under the skin, these compounds are capable of producing tumors of important internal organs, such as the lungs, kidneys, bones, spleen, prostate, brain, etc. (For further details on the subject of carcinogenesis by polycyclic compounds see Cook and others, 1937; Fieser and others, 1937; Cook and Kennaway, 1938; and Fieser, 1938).

There is another field of industrial chemistry which has been found to have bearing on the genesis of tumors. There are 2 dyes, both of which are sometimes called "Butter Yellow," which are used industrially. One of these dyes, Schultz No. 68, is also commonly called "Spirit Yellow R" and "Yellow Fat Color." In the "Colour Index of the Society of Dyers and Colourists" it is listed as No. 17, with 12 additional commercial names.

In 1936, Dr. Louis Schwartz, Senior Surgeon in Charge of Dermatoses Investigations of the United States Public Health Service, published a report on dermatitis from wrist watch straps. A manufacturer of wrist watches had received complaints that wearers of these wrist watches developed dermatitis of the skin under the wrist watch straps, and asked the Public Health Service to investigate this health hazard.

Dr. Schwartz found the dermatitis to be due to a dye

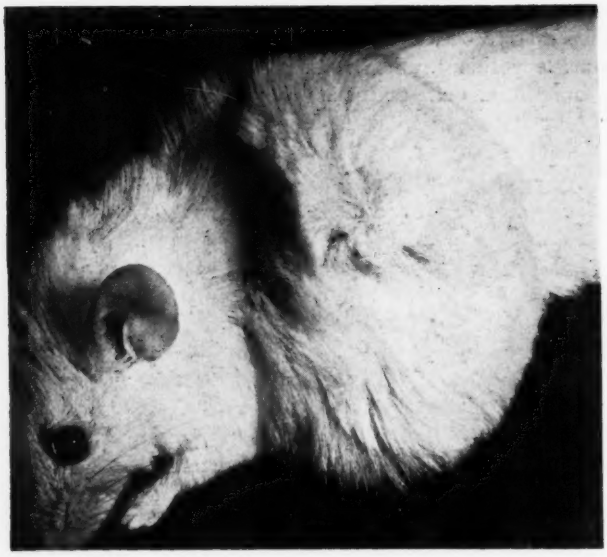


Fig. 3—Photograph of a mouse (strain A) bearing a large subcutaneous tumor which developed at the site of injection of 10-ethyl-1,2-benzanthracene. The photograph was taken 13 months after 5 mg. of the crystalline hydrocarbon had been introduced under the skin.

Fig. 4—Photograph of a mouse (strain A) showing the ulceration which developed at the site of injection of 9,10-dimethyl-1,2-benzanthracene. The photograph was taken 31 days after 1 mg. of the hydrocarbon (dissolved in 0.2 cc. lard) had been introduced under the skin. This mouse illustrates the severe ulceration, and emaciation, which result from the subcutaneous injection of some of the potent carcinogens. This type of ulceration occurs early, and precedes tumor formation.

Fig. 5—Photograph of the lungs of a mouse (strain A) showing multiple small tumors. The photograph was taken 4 months after 1 mg. of 20-methylcholanthrene (in 0.2 cc. lard) had been introduced under the skin.

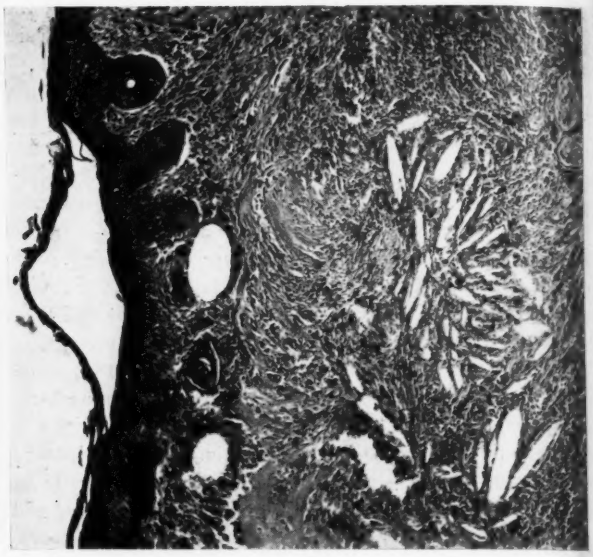


Fig. 6—Photomicrograph of the skin and subcutaneous tissues of a mouse (strain A) showing the tissue reaction around crystals of 20-ethylcholanthrene which has been injected 5 months previously.

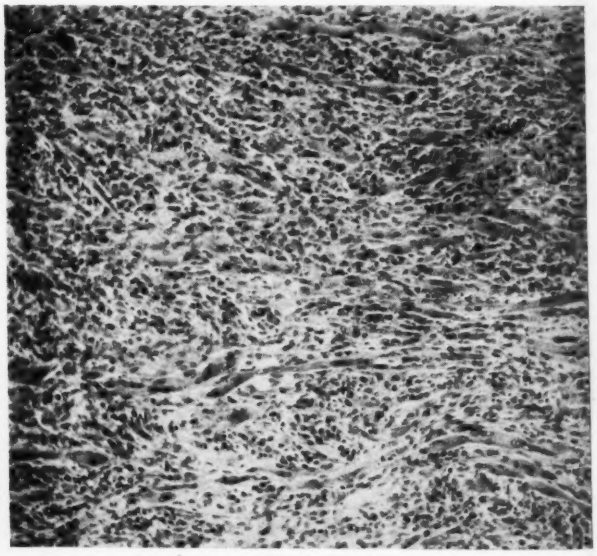


Fig. 7—Photomicrograph of a sarcoma, which developed at the site of injection of crystalline 10-methyl-1,2-benzanthracene in a mouse (strain A), showing multinucleated tumor giant cells.

used to color the leather straps. Since the black dye had conferred a blue-black color to the leather, a yellow dye was added for shading. Dr. Schwartz found that it was this yellow dye that was responsible for the skin damage.

At this same time we were preparing for publication the results of experiments in which this same dye, 2-amino-5-azotoluol, had been injected under the skin of mice, and which, after about a year, produced a striking picture of multiple tumors of the liver (Shear, 1937).

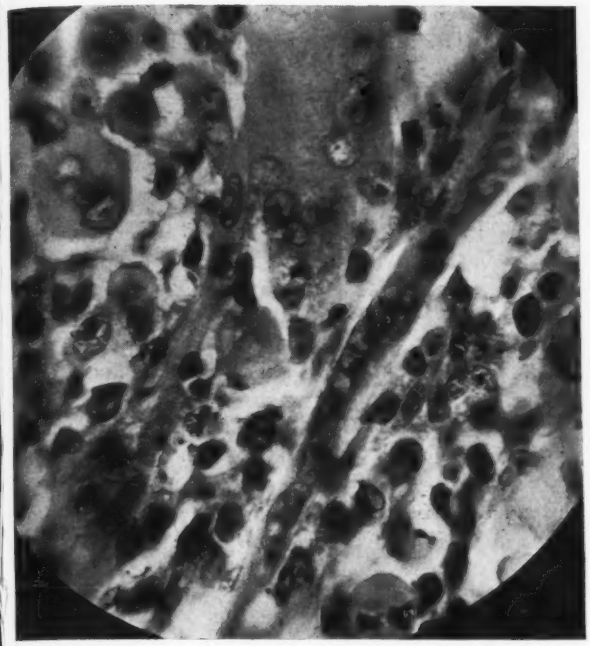
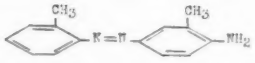


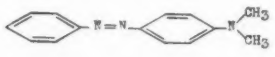
Fig. 8—Photomicrograph (high magnification) of tumor giant cells, similar to those shown in Fig. 7, in a sarcoma which developed around a cholesterol pellet containing 5 per cent 3,4-benzyprene. This tumor developed 3 months after the pellet had been introduced under the skin of the mouse (strain A).

Fig. 9—Photograph of the skin and subcutaneous tissues of a mouse (strain A) showing the tissue reaction around a 5 per cent benzpyrene-cholesterol pellet 34 days after its introduction under the skin. This rapid proliferation of tissue around such pellets is a stage in the development of malignant tumors.



This dye is the p-amino derivative of azotoluol. It was first found to be cancer-producing in 1934 by Yoshida, a Japanese investigator, who fed the dye, mixed in the food, to rats. Cancer of the liver and of the bile ducts resulted. These feeding experiments are of particular interest since this dye has been used to color oleomargarine to make it resemble butter and is also used to color the rind of green oranges to make them more salable.*

There is another dye, a p-dimethylamino derivative of



*Personal communication from Dr. Louis Schwartz.

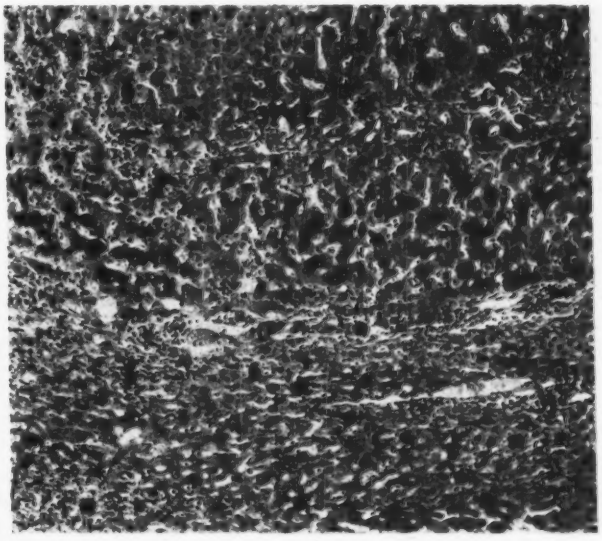


Fig. 10—Photomicrograph of a liver tumor induced in a mouse following repeated injection under the skin of 2-amino-5-azotoluol ("ortho-amido-azotoluol"; "butter yellow").

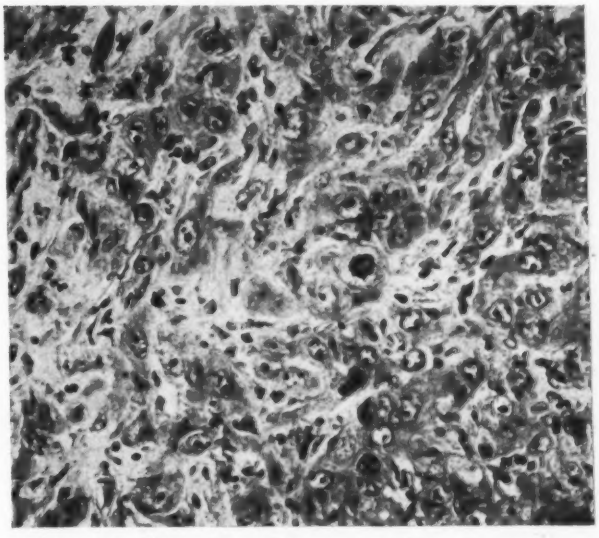


Fig. 10A—Higher magnification of the liver cell carcinoma shown in Fig. 10.

azobenzene which is also called "Butter Yellow" and which also produces cancer of the liver when fed to animals, according to more recent reports from Japanese laboratories. This dye is Schultz No. 32, and is also called "Oil Yellow." It is No. 19 in the Colour Index. It, too, is said to be used to color butter and oils yellow. (For further details of the subject of dyes in cancer, see Shear, 1937, and Kinosita, 1937).

A third class of substances, that is responsible for producing cancer of the urinary bladder in workmen in certain chemical industries, has not yet been definitely identified. For several decades it has been accepted in Europe

that workmen in certain departments of chemical plants develop cancer of the bladder that is attributable to exposure to the chemicals handled. An apparently strong argument against that conclusion was the fact that although the chemical industries in the United States employed many workmen, such results were not obtained in this country.

However, in recent years there have occurred a sufficiently large number of cases of cancer of the urinary bladder in workmen in the chemical plants in this country so that this argument is no longer valid. The explanation offered is that it takes a long time for the cancer to develop and that, since the great growth of the chemical industry in this country is of rather recent origin, not enough time had elapsed until recently for this undesirable result to make its appearance.

There seems to be no doubt now that this type of cancer is of occupational origin in the case of such employees. The identification of the compounds responsible has not yet been made, although substances of the type of aniline, benzidine and β-naphthylamine are suspected. Work along this line has been going on in various laboratories, including those of the Public Health Service, and more information is being slowly accumulated on this point. [For details see "Symposium on Anilin Tumors of the Bladder" (1934); Hueper (1934); Berenblum and Bonser (1937); and Hueper, Wiley and Wolfe (1938)].

With respect to causation of cancer, lubricating oil appears to be less of a problem in this country than in Europe. This has been ascribed to the fact that the oils employed here are more refined, especially as regards the removal of unsaturated benzenoid hydrocarbons.

Specifications for lubricating oil for use in the textile industry have been described by Twort in the Report of the Manchester [England] Committee on Cancer for 1932-1934. Revised specifications* were described in the report of this committee for 1935. Since these reports are not readily available, these specifications are reproduced here, as follows:—

"As regards the provisional recommendations concerning mule spindle oils referred to on page 14 of our report for 1932-4, we have been informed by representatives of the Institution of Petroleum Technologists that it would be more convenient for the oil industry were our recommendations expressed in a somewhat different manner, our refractivity figures of 0.5539 and 0.5569 of course remaining unaltered. The amended specification suggested is:—

"Mule spindle mineral lubricating oils should have a specific refractivity below 0.5539 when the specific gravity is above 0.895, or a specific refractivity below 0.5569 when the specific gravity is below 0.895. By specific gravity is meant the specific gravity at 60° F. in relation to water at 60° F. vacuo/vacuo.

"By specific refractivity is meant $\frac{n-1}{d}$ where n is the refractive index for d line sodium light, and where d is density in grammes per millilitre at 20° C. The specific gravity shall be determined by the method laid down in standard methods for testing petroleum and its products, published by the Institution of Petroleum Technologists.

"The density shall be determined by means of a pyknometer or bottle having a minimum capacity of 10 millilitres or by a density hydrometer. If the latter is employed it shall conform to the British Standards Specification No. 1A or No. 2A. The thermometer employed must be accurate to within ±0.1° C.

"The refractive index is to be determined by any recognized form of refractometer provided that it is capable of giving results to an accuracy of ±0.0005. This instrument should be calibrated and periodically checked with liquids of known refractive index, such as carbon tetrachloride or benzene.

"Special care must be taken that the temperature of the sample is in equilibrium, and that of the bath temperature controlled to ±0.5° C."

As regards dyestuffs, two commercial dyes were mentioned this evening as having been found to be cancer-producing. This does not mean that all the other dyes are necessarily safe in this regard.

There have been a number of studies made of dermatitis which occurred in workmen in certain industries and in consumers who used clothing of recent manufacture. In the latter category were cases of dermatitis from dyed socks, from shoe leather, from dyed shirts, and so forth. Patch tests showed that in many instances the trouble was due to the dye employed; in other cases it was due to some other chemical used in the manufacture of the item of clothing.

"Bleeding" of the dye from such items of clothing is not uncommon. It is easy to picture the solvent effect of body perspiration on such dyed clothes, and to visualize how the resultant solution of dye in perspiration would be in intimate contact with the skin. The local skin irritation, or the toxic effects on the body as a whole, have been the objects of investigation to some extent. But our present concern is not so much with such effects as with the possible cancer-producing activity of some dyes and related compounds. From this point of view, the person who has a "sensitive" skin and who develops itching, irritation and skin damage may perhaps be considered lucky. For he is annoyed so much that he sees that the offending chemicals are removed. If, however, he does not happen to have a "sensitive" skin, he may possibly be absorbing small amounts of dye into his body through his skin over long periods without being aware of it.

*For a more recent discussion of the relationship between the physical characteristics and biological properties of mineral oils, the reader is referred to a paper by C. C. Twort and J. M. Twort which appeared in "The Oil and Colour Trades Journal," July 22 and 29, 1938.

We do not intend to paint an alarming picture of this situation, nor do we wish to give the impression that many of the dyes in common use are cancer-producing. The point which we do wish to make is that little is known about this particular aspect of the subject, and that it appears to be advisable to obtain definite information on this matter.

These findings are comparatively recent. Consequently few of the large number of dyes and other chemical compounds used in textiles, leather and other items of clothing that come into contact with human skin have as yet been tested to ascertain which of them may be cancer-producing. The same holds true of the many dyes used in food intended for human consumption. In a few instances only has it been found feasible to examine such substances to date in the laboratories of the Public Health Service. The only extensive work along this line is that being carried on in Japan.

In 1916 Salant and Benges, in the laboratories of the United States Department of Agriculture, studied the biological effects of a number of azo compounds used in industry. These authors stated "Although synthetic dyes have played an important part in the study of biology and medicine, the behavior of many of these compounds in the body is still imperfectly understood and the action of some of them entirely unknown. Owing to their extensive employment in numerous industries, and especially in the preparation of foods, this lack of satisfactory information frequently proved to be a matter of serious import as questions regarding their effect on health were often raised, but no definite answer could be given in the present state of our knowledge."

As regards the effect of such types of compound on the causation of cancer, the statement which Salant and Benges made 23 years ago is applicable today.

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Abstracts of

Papers

to be presented at the

Nineteenth Annual Meeting

Appear on Page P446

THE CONVENTION CITY

The Textile Collections in the Boston Museum of Fine Arts

For textile chemists and colorists the choice of Boston for the September meeting of the American Association of Textile Chemists and Colorists is a fortunate one because in the Boston Museum of Fine Arts is found one of the greatest collections of textiles in the Americas. It is widely acclaimed not only for its historical value but for the beauty of its individual pieces. The range of examples illustrate types of textiles from the earliest centuries of the Christian Era to the present time. There are weavings from the Coptic burial grounds of Egypt and from the pre-Inca graves of Peru, which are vigorous in color and design. The collection of Peruvian textiles is one of the three important Peruvian collections in the United States and presents a fairly complete record of the textile achievements of Peruvians from the first centuries to the present time. Tapestries, embroideries, painted cloths and other fabrics of various weaves are found in this group, which as everyone knows, is rich in suggestions for color and design.

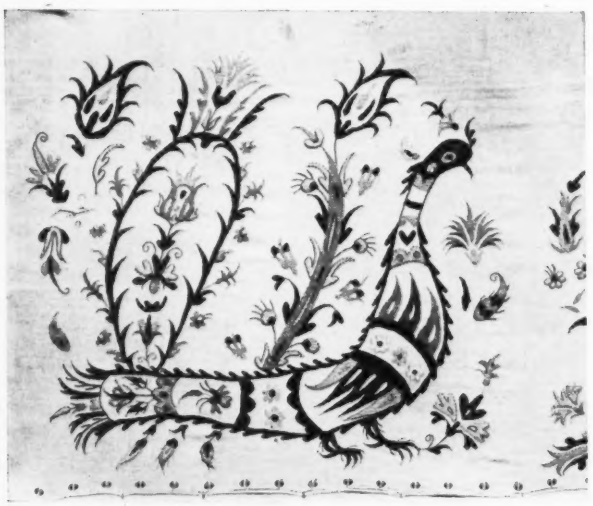
There are examples of early European silk weaving, among them a twelfth century chasuble and a thirteenth century mitre, both from the Abbey Church of St. Peter in Salzburg. A group of very important European silks of the thirteenth and fourteenth centuries date from that transitional period in which can be traced the development of the weaving of rich fabrics of silk and gold from a distinctly Oriental art to its culmination as a European art. Among them are two thirteenth century Spanish-Arabic brocades and silks of the thirteenth century Romanesque designs carried out in the city of Ratisbon on the Danube. The fifteenth century Italian velvets are among the finest examples extant in this country. One of velvet and gold brocade has a floral design of eastern origin, another of Florentine velvet dates from the second half of the fifteenth century, a period during which the products of Florentine looms were unsurpassed in Europe.

Equally notable is the Museum's collection of tapestries. The great "Passion Tapestry," which hangs in the central tapestry hall, came from Knole, Kent, in England. With it have been associated some of the outstanding personalities of English history,—Bishop Warham, the Sackville family, Queen Elizabeth and others. Before coming to the Museum the tapestry hung in the little chapel of Knole House. There are also tapestries of Italian, Flemish, French, and Fraeco-Flemish make which are marvels of color and design.

From Italy, France and Flanders come embroideries and lace for the Museum Collection and from Asia, Asia Minor, and Indonesia, a collection of brocades, embroideries and printed silks and cottons remarkable for richness of color and design. There are sixteenth century Persian rugs, Persian and Indian brocades and embroideries, and a magnificent collection of Chinese and Japanese robes and other woven and embroidered textiles.

A recent gift of the greatest importance to the Museum is a collection of textiles consisting of three hundred and fifty pieces of European embroidery, lace and weaving, dating from the fifteenth though the eighteenth century, presented to the Boston Museum by Mr. Philip Lehman of New York in memory of his wife, Carrie L. Lehman.

The Boston Museum of Fine Arts is open free daily except Monday from 9 to 5 and on Sundays from 1 to 5. The Museum is closed on Monday. Over the years the Museum has cooperated with manufacturers and designers in their study of old designs and techniques — a service which is free.



Right—Peruvian Tapestry. Period: 900-1100 A.D.

Left—Detail of Bedspread from Skyros. Period: Greek, 18th Century.

Photos, Courtesy, Museum of Fine Arts, Boston.

ANNUAL MEETING AND CONVENTION BOSTON, MASSACHUSETTS — SEPT. 15th and 16th

UNEMPLOYMENT REGISTER

Members of this association, who are without employment, should forward to the secretary a statement as to their qualifications and experience. This information will subsequently appear on these pages with an identifying key number. Employers are also requested to file with the secretary or the American Dyestuff Reporter any vacancies which may occur in their businesses.—H. C. Chapin, Secretary, Lowell Textile Institute, Lowell, Mass.

Key: A—Laboratory and research; B—Dyeing or printing; C—Finishing; D—Sales; E—Instruction; F—Executive.

NOTE: PERSONS WHO HAVE OBTAINED EMPLOYMENT SHOULD NOTIFY THE SECRETARY OR THE AMERICAN DYESTUFF REPORTER AT ONCE.

IMPORTANT NOTICE
To Prospective Employers

Complete personal histories and employment records of the following applicants are now on file at the office of the American Dyestuff Reporter and with the secretary of the Association. These may be examined by prospective employers or copies will be loaned upon application.

A-1

Education—A.B., Chemistry, Cornell; 2 years organic chemistry abroad; knowledge of German.

Experience—Six years as chemist for large silk throwing concern; testing and application of dyes and textiles specialties in silk soaking; development work for yarn lubrication and moisture conditioning; familiar with knitting and finishing of hosiery. Laboratory work preferred.

Age 31; single.

A-B-7

Education—Evening school in textile dyeing and chemistry.

Experience—Dyehouse laboratory for 2 years. Foreman dyer and finisher on hosiery for 9 years. Experience on ribbons also vat dyes on rayon and silk skeins. 2 years assistant to superintendent. Desires position either in demonstrating and sales or dyer; New York Viciniy. Age 33; married.

A-B-8

Education—Graduate Chemist.

Experience—Print superintendent, colorist; eleven years' experience in all types of fabrics, specializing on rayon; 8 years' dyestuff laboratory and demonstrating. Excellent references; age 36; married.

A-B-9

Education—Bradford Durfee Textile School, 1918, chemistry and dyeing course.

Experience—Dye application, textile and color chemist; good general factory, laboratory and office experience; accustomed to assuming responsibility; handled all types of help; purchased chemicals, dyes, etc.; executive ability; good personality.

Age 42; American, married; will go anywhere for interesting work; references.

A-B-10

Education—1 year of textile chemistry, day course, Philadelphia Textile School; also business course.

Experience—3 years as apprentice in weaving mill in Germany, office and stock room, general clerical work, practice in all departments of cotton manufacture, dyeing, bleaching and finishing of cotton-rayon mixtures, piece and package processing; several mos. in laboratory of German dyestuff manufacturer, dyestuffs and assistants and their application, vat and naphthol dyeing.

Ago 20; will go anywhere in U. S.

A-B-C-4

Education—Educated abroad.

Experience—Twenty years experience in the textile field as bleacher, dyer, finisher and chemist. 16 years in charge of dyestuff laboratory of large dyeing plant, 4 years as chief chemist with large bleachery. Has tested dyestuffs, and chemicals used in the textile field and has manufactured soaps and textile specialties. Has handled all textile fibers; bleaching, printing, dyeing and finishing same. Has done pigment and lacquer printing, waterproofing and fireproofing. Reason for leaving last position was due to business conditions.

Age 41; married.

A-B-C-6

Education—English Municipal School of Technology; Board of Education, So. Kensington Chemistry Certificates; City & Guilds of London Institute in Bleaching and Dyeing.

Experience—In U. S. A. 22 years as chemist and chief chemist with one of the largest textile plants in the country; expert colorist; long experience with permanent and semi-permanent finishes. Specialist on vats, naphthols and indigosols. Age 50; married.

A-B-C-7

Education—B.S. in Textile Chemistry and Dyeing, 1939, North Carolina State College.

Experience—None. Seeks position as textile chemist and colorist. Age 21; single.

A-B-C-8

Education—B.T.C., 1933, Lowell Textile Institute.

Experience—5 months as rayon slasher tender; 8 months color matching, dye testing and analytical work; 5 years with large print works in rayon finishing department, laboratory, color matching, dye testing, assistant rayon dyer. Seeks position as rayon dyer, assistant dyer, or any job in a rayon dyeing and finishing plant. Age 29; single.

A-B-C-9

Education—Lowell Textile Institute; chemistry, dyeing and textile finishing.

Experience—Twelve years head dyer in hosiery mills. Dyeing all types of fibers and in combination. Knowledge of all dye applications. Matching and formula making. Charge of every department in a hosiery mill except fixing machinery. Has done jigg work on cottons and rayons. Desires position in hosiery, or in any field. Would like to work as an assistant to head dyer in a woolen or rayon mill. Age 42; married. Will go anywhere in the United States.

A-B-C-D-1

Education—Lowell Textile Institute, Baehelor of Textile Chemistry; Lowell Textile Institute (Evenings), 2 years D. C. Electricity; 2 years A. C. Electricity.

Experience—Six years as chemist and assistant dyer with a large organization. Specialized in dyeing, finishing, bleaching and drying of woolens, worsteds, cottons, rayons and unions in the piece. Some sales experience. Desires position as chemist, dyer, finisher, bleacher or sales. Age 30; American citizen; Married.

A-B-C-F-1

Education—Textile institute course; extension work at Brown; executive training with Alexander Hamilton Institute; knowledge of German.

Experience—Dyeing executive in all types of textiles, including stock, yarns, and piece-goods. Thorough knowledge of all classes of dyes and dyestuffs, and their successful practical application in the plant. Wide experience in all types and makes of equipment used in dyeing, bleaching, mercerizing and finishing. Laboratory practice in planning and checking methods and processes, costing and purchasing. Good manager personnel for efficiency and satisfactory results economically obtained. Cotton, rayon and silk, some acetate rayon, and mixed fabrics. Excellent references; in excellent health.

A-B-C-F-2

Education—Lowell Textile Institute, 1911.

Experience—26 years in cotton yarn and piece goods finishing plants; expert on naphthols, vats and other cotton and rayon dyeing; all types of control work and testing; analytical processes; purchasing of dyes and chemicals. Age 46; excellent references; in perfect health; will go anywhere; married.

B-4

Experience—Foreman dyer in charge of ribbon dyeing for 20 years. Experienced on silk, cotton, rayon, acetate yarn. Age 41; will go anywhere.

B-5

Education—High School and Textile School Graduate.

Experience—Twelve years overseer of dyeing on directs, vats, naphthols, sulfur, basic and developed colors. Also experienced bleacher. Age 40; married; references.

B-6

Education—Textile School Graduate.

Experience—Former instructor in chemistry and dyeing. Twelve years' experience as overseer of dyeing of vats, naphthols, developed, indigosols, sulfur and direct colors on piece goods. Age 35; excellent references.

B-7

Education—Municipal School of Technology, England. Chemistry certificates of Board of Education, So. Kensington. Bleaching, Dyeing and Printing Certificates of City Guild of London Institute.

Experience—In U. S. A. 16 years as assistant and colorist in large plants, all styles of fabrics.

Age 46; married.

B-C-3

Education—Graduate, Philadelphia Textile School; speaks German fluently.

Experience—Employed at velvet company for 7½ years. Past 2 years working in finishing department on regular, waterproof and crush-resistant finishes (resin finishes). Can take charge of finishing of velvets. Have some piece dyeing experience.

29 years of age; married; will go anywhere.

F-1

Education—Two years high school; 6 years evening engineering school; 1 year evening textile school; 1 year industrial management; course in accounting.

Experience—Ten years in an executive capacity in full fashioned hosiery manufacturing business. Familiar with entire manufacturing procedure, finishing dept., dyehouse and office. Specialized in finishing dept. and has good eye for color, finish and quality. Had responsibility of all orders going through mill, stock, grey goods and traffic. Five months in New York sales office. Gets along well with people and contact with employees and customers has always been satisfactory. Previous to hosiery experience was in a mechanical business for 17 years.

43 years of age; single, in good health; will go anywhere.

ANNUAL MEETING AND CONVENTION

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BOSTON, MASSACHUSETTS SEPTEMBER 15 AND 16

Physical and Chemical Textile Testing—XVI

JOHN H. SKINKLE

PART III—MICROSCOPICAL TESTING

(Continued from July 10, 1939 issue)

Chapter 16—Identifications

INTRODUCTION

SINCE it would be impracticable here to discuss fully the construction and use of the microscope and accessories, it will be assumed that the reader is acquainted with the microscope and has sufficient practice on methods so that detailed descriptions of operations need not be given. Before any microscopical testing is done, it is essential that a knowledge of fundamentals be obtained from the references given here and that sufficient practice be obtained on samples of known composition and properties so that the technique of the art is familiar. No photomicrographs are given for the recognition of the fibers because there is so much variation in individual fibers that a false idea of what to look for might be obtained; instead, it is strongly recommended that a collection of known samples be made and kept available for comparison, so that not only the ordinary appearance but any normal variations in appearance may be known.

We have seen in Chapter 12 that it is impossible to finally and definitely recognize every fiber by chemical means alone, the microscope alone will do this but a combination of chemical and microscopical methods usually removes all doubt. An additional advantage of microscopical testing is the fact that very small samples may be used and that the samples are not destroyed.

REFERENCES

(1) Skinkle, J. H. Elementary Textile Microscopy. Howes Publishing Co., New York, 1930.

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(3) Schwarz, E. R. Textiles and the Microscope. McGraw-Hill Book Co., New York, 1934.

(4) Hardy, J. Method for Studying the Scale Structure of Medullated and Pigmented Animal Fibers. Journal of the Textile Institute *23*, T1 (1932).

(5) Manby, J. Improved Method for Revealing the Scale Structure of Wool and Hair. Journal of the Textile Institute *23*, T5 (1932).

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(7) Osborne, G. Micro-Analysis of Textile Fibers. Textile Research *4*, 84 (1934); *5*, 75, 275, 307, 351 (1935).

IDENTIFICATION OF STARCHES

The identification of a starch depends upon three characteristics: the size, the shape, and the presence or absence as well as the shape of a marking on the starch grain called the hilum. Table XX gives the appearance of the more common types of starch when freshly prepared. It will be noted that there are three sizes of starch grains (small, medium, and large); three shapes (polygon, circular, and oval) of which the circular and oval may be truncated (cut off); and three types of hilum, dot, transverse (one line), and stellate (two or more intersecting lines).

The identification is fairly easy on a freshly prepared starch but is complicated on an old starch, a boiled starch, or a chemically modified starch (dextrine) by the fact that on these treatments the hila change from dot to transverse, transverse to stellate, and stellate to ruptured grains; too much reliance, therefore, must not be placed on the appearance of the hilum unless the history of the starch is known. A magnification of 100x should be used for most work, with a 400x magnification available for closer examination of individual grains. A comparison of the unknown with known samples is always desirable.

TABLE XX
Microscopical Appearance of Starches

	Size	*Shape*	*Hilum**
Rice	Small 3-10μ	Polygon	None
Corn	Small, medium 10-30μ	Polygon	Stellate
Wheat	Small, large 1-8μ, 15-45μ	Circular	None
Tapioca	Small, medium 5-26μ	Circular (truncated)	Dot
Potato	All sizes	Circular (S, M) Oval (L)	Dot on large grains
Arrowroot	Medium, large 35-70μ	Oval	Dot or transverse
Sago	Medium, large 30-65μ	Oval (truncated)	Dot or transverse

*This refers only to starch which has not been altered by age, heating, or chemical treatment.

TABLE XXI
Microscopical Appearance of Hairs

Name and Natural Color	*Wool hairs*	*Beard hairs*	*Remarks*
WOOL (white)	Scales project, loosely arranged D = 12-70μ S = less than 18μ S^3/D = less than 140	Not many, except in "luster wools"	
MOHAIR (white)	Scales close to surface D = 14-90μ S = greater than 18μ S^3/D = greater than 160	Not many	Much kemp
CASHMERE (white, grey, brown)	Scales project slightly, serrated. White and grey have striations, brown has color granules D = 14-16μ (average) S = 14-17μ	Medulla makes up large part of fiber D = 30-150μ	Roots and tips present, tips usually broken
COMMON GOAT HAIR (white, grey)	D = 7-20μ	Mostly beard hairs Roots present D = 50-200μ	
CAMEL HAIR (brown)	Scales diagonal Striated, color granules Some interrupted medullas D = 9-40μ, 18-24μ (ave.) S = 11-16μ	Wide, continuous medullas D = 30-120μ	
LLAMA (white, brown)	Scales indistinct Striated, color granules Few non-medullated fibers D = 10-60μ, 20-27μ (ave.)	Double channel medullas	
ALPACA (white, grey, black, brown)	Scales indistinct Striated, color granules Indistinct hollow medulla Few non-medullated fibers D = 10-60μ, 26-27μ (ave.)		
VICUNA (white, fawn, brown)	Scales indistinct Striated, color granules Few non-medullated fibers D = 6-25μ, 12-14μ (ave.)	D = 68-80μ	

D = diameter of fiber in microns
S = visible scale length in microns

In the case of greatly decomposed starches, identification must depend upon the examination of the few grains that are left intact.

REFERENCES

(1) Skinkle, J. H. Elementary Textile Microscopy. Howes Publishing Co., New York, 1930.

IDENTIFICATION OF FIBERS

In Chapter 12, in considering the qualitative tests for the various fibers, it was strongly recommended that the microscope be used to amplify and check the chemical tests and also to identify members of groups which could not be differentiated by chemical means. In considering the microscopical analysis of fibers, we shall classify the fibers according to origin, rather than according to chemical constitution, into:

1. Hairs.
   a. Sheep family—wool.
   b. Goat family—mohair, cashmere, common goat hair.
   c. Camel family—camel hair, llama, alpaca, vicuna.
2. Silks—true silk, tussah silk.
3. Vegetable seed hairs — cotton, mercerized cotton, kapok.
4. Vegetable stem fibers—flax, ramie, hemp, jute.
5. Rayons, of cellulose origin—acetate, cupra, viscose, stretch-spun viscose.
6. Artificial fibers, of other than cellulose origin—casein wool, casein-viscose mixture, Nylon, vinyl resin.

TABLE XXII
Microscopical Appearance of Bast Fibers

	Joints	*Lumen*	*Natural ends*	*Cross-Section-shape*	*Cross-Section-lumen*
Flax line	Present	Narrow	Pointed	Sharp polygons	Small, round
Flax tow	Present	Broad	Pointed	Sharp polygons	Larger, oval or round
Ramie	Present	Broad	Blunt	Elongated rounded polygons	Polygons with radial cracks
Hemp	Present	Broad, indistinct	Blunt	Rounded polygons	Cleft-shaped
Jute	Absent	Broad, variable	Blunt	Sharp polygons	Oval or round

TABLE XXIII
Microscopical Appearance of Artificial Fibers

Fiber	*Longitudinal Appearance*	*Cross-sectional Appearance*
Acetate rayon	False lumen	Bulbous, indentations
Cupra rayon	No markings	Small, nearly round
Viscose rayon	Numerous striations	Various, but always with a serrated edge
Stretch-spun viscose rayon	Indistinct striations	Various, indistinct serrations
Casein-viscose (Cisalfa type)	Similar to viscose	Similar to viscose
Casein wool (Lanital type)	Fairly smooth, longitudinal striations	Irregular shape, frequent indentations, occasional serrations
Condensed amines and acids (Nylon type)	No markings	Small, round
Vinyl resin	Narrow false lumen	Irregular, flattened circles, often curved

Note: the above appearances are for the lustrous types of fiber; the delustered fibers have the same shapes but contain numerous small particles of delustering agent.

In identifying hairs, the chief points of interest are the size and shape of the scales, presence or absence of color granules in the cortex, presence and size of the medulla, and finally the diameter of the fiber. It should be remembered, also, that both wool and beard hairs exist and differ considerably in their properties. Known samples should be available for comparison and amplification of Table XXI which summarizes the properties of the hairs. Of all of these wool, mohair, and camel hair are by far the most common; and the hardest distinction to make is between certain wools and mohairs. Skinkle's scale length method may be used for this: if the visible scale length is below 17μ, it is wool; if above 18.5μ, it is mohair; if between 17 and 18μ it is probably wool and between 18 and 18.5μ it is probably mohair, in this last case measure also the diameter and calculate S^3/D, if this last value is below 140 it is wool and if above 160 it is mohair.

Hairs are best examined in a mount of glycerine or colorless mineral oil and at a magnification of 100x; higher magnification may be required for individual fibers. The mounting technique of Manby may be used and the method of Hardy for making casts of the fibers is useful on dyed or heavily pigmented hairs to study the scale structure.

Lambs' wool and hogg wool may be identified by the presence of natural tapering fiber ends. Pulled wool shows occasional root ends, some broken ends, and occasionally crystalline particles which adhere to the fiber. Shoddy or reworked wool may be recognized by the torn or broken ends, cracked and broken bends, and usually by the large number of colors present.

The silks are easily distinguished from each other; true silk is a narrow fiber with no markings; tussah silk is a broad fiber with longitudinal striations, particles of colored pigment, and frequently with parallel pairs of diagonal lines. The cross-sections of true silk are quarter circles or half circles (with sharp corners rounded off), the cross-sections of tussah are very much flattened circles.

In the vegetable seed hairs, cotton is distinguished

TABLE XXIV

Microscopical Recognition of Fibers

Make longitudinal mount of fiber in mineral oil and examine at 100x mag.

Scales present	*Twisted or bent*	*Joints present*	*Longitudinal striations*	*No markings*
HAIR	COTTON KAPOK	RAMIE, HEMP, FLAX	TUSSAH, JUTE, ACETATE, VISCOSE, CISALFA, LANITAL, VINYL RESIN	SILK, MERC. COTTON, CUPRA, NYLON
See Table XXI	Cotton: twisted, thick walls Kapok: bent, thin wall	See Table XXII	Jute: broad lumen, polygonal cross-section Tussah: color granules, diagonal marks Acetate: few striations, apparent lumen, nearly invisible in mineral oil Lanital: irregular indented cross-sections Vinyl resin: flattened circles in cross-section Viscose, Cisalfa: numerous striations, serrated cross-sections	Merc. Cotton: remnants of lumen Silk: triangular cross-sections Cupra, Nylon: round cross-sections
	Confirm Kapok with chemical test	Confirm Hemp with chemical test	Confirm 1. Jute 2. Acetate 3. Tussah, Cisalfa, Lanital 4. Vinyl resin with chemical tests	Confirm 1. Silk 2. Nylon with chemical tests

easily from kapok by the fact that the cotton is a broad flat fiber with frequent twists, a broad lumen is present but the walls of the fiber are quite thick; kapok consists of a circular hollow tube with a broad lumen, very thin walls and frequent bends but no twist. Mercerized cotton is rounder, without twist, and the lumen has disappeared or become very narrow. Incompletely mercerized cotton has fibers of both types and should be given the "deconvolution count" (see Chapter 17) for recognition.

Table XXII gives the characteristics of the vegetable stem fibers or bast fibers. These fibers are found in bundles, cemented together, and it is necessary to break up the bundles and obtain the individual fibers before recognition may be made. It will be noted that jute is distinguished from the others by the absence of joints and flax is distinguished by the pointed end. If chemical tests can be used, the longitudinal appearance is all that is necessary but if recognition must be done by the microscope, then cross-sections should be prepared. Polarized light is useful in quickly deciding whether joints are present, and Hardy's sectioning device for preparing cross-sections. It will be noted that flax line and tow may be distinguished by the width of the lumen. Bast fibers are best mounted in water and examined at about 200x magnification.

Table XXIII gives the microscopical appearances of the artificial fibers, both the cellulose type (rayons), and the non-cellulose type (newer fibers). Both longitudinal and cross-sectional mounts must be made and it is almost a necessity that chemical tests be used to amplify the microscopical appearances. The appearances of the newer fibers are given as they are now made but it is possible that changes in manufacture may alter these appearances, therefore some known samples are necessary for comparison.

In first looking at a fiber, it is generally possible to assign it to one of several groups as shown in Table XXIV. After that, the observing of further details will generally identify the fiber, but it is better and safer to check results by preparing a cross-section and making suitable chemical tests as given in Chapter 12.

References

(1) Skinkle, J. H. Elementary Textile Microscopy. Howes Publishing Co., New York, 1930.

(2) A.S.T.M. Standards on Textile Materials. A.S.T.M., Philadelphia, 1938.

(3) Von Bergen, W. and Mauersberger, H. R. American Wool Handbook. American Wool Handbook Co., New York, 1938.

(4) Garner, W. Textile Analytical Microscopy. Journal of the Society of Dyers and Colourists *42*, 269 (1926).

(5) Skinkle, J. H. Determination of Wool and Mohair by Scale Size and Diameter. American Dyestuff Reporter *25*, 620 (1936).

(6) Von Bergen, W. Wool and Mohair. American Dyestuff Reporter *26*, 271 (1937).

(7) Rayon Identification. American Dyestuff Reporter *23*, 457 (1934).

TRADE NOTES • NEW PRODUCTS

• GENERAL RELEASES

General Dyestuff Corp., 435 Hudson St., New York City, has recently released a circular describing the following product:

Palatine Fast Black G G N—this will replace Palatine Fast Black G G. The new product is of interest for the production of greenish blacks or dark greens. It is said to possess excellent fastness to light and good fastness to water, washing and rubbing. It is further said to have very good fastness to hot pressing and the fastness to perspiration is characteristic of the Palatine Fast range. It is stated that the new dyestuff levels well, is very soluble and suitable for machine dyeing. It also can be used for direct prints on wool or silk. Circular No. 1667.

• R & H BULLETIN

R & H Chemicals Dept., E. I. duPont deNemours & Co., Inc., has recently issued a bulletin entitled "Control of pH in Peroxide Solutions" by J. S. Reichert and H. G. Hull. A preliminary statement reads as follows:

"Control of pH is important in processes involving the production and applications of the peroxygen compounds. The applicability of colorimetric and potentiometric methods for measuring the pH of peroxide solutions is discussed and data are presented showing relationships between pH and normality of hydrogen peroxide solutions in concentrations up to 200 volume. Hydrogen peroxide behaves like a weak acid and increases the hydrogen-ion activity of sulfuric acid in proportion to the peroxide concentration."

The bulletin represents a reprint from the June 15, 1939, Analytical Edition of *Industrial & Engineering Chemistry*. Copies are available upon request.

• RHOPLEX RESINS

Rohm & Haas Co., Inc., 222 West Washington Sq., Philadelphia, Pa., has recently released the second in a series of circulars describing the RHoplex resins. This series presents a discussion of the outstanding properties of these acqueous dispersions and suggestions for their application to textiles. Copies are available upon request.

• NEW FOLDER ON "CELLOSOLVE" SOLVENTS

Carbide and Carbon Chemicals Corporation announces the publication of a new folder entitled "Cellosolve Solvents." Known as Chemical Group Folder No. 3, this publication is the third of a series of pamphlets designed to present, briefly and concisely, information on industrial organic chemical families. This folder describes eight "Cellosolve" ether-glycols and two "Cellosolve" ether-glycol acetates. A convenient table presents their principal properties—boiling points, specific gravities, flash points, toluol or xylene dilution ratios, solubilities in water and hydrocarbons, as well as solvent powers for certain resins.

The "Cellosolve" compounds actually belong to three chemical families—the ethers, the hydrocarbons, and the alcohols. They show exceptional dissolving powers, and are particularly interesting to solvent-consuming industries. The group of solvents offers a wide choice of boiling points and evaporation rates and is thus useful in many applications. Copies of "Cellosolve Solvents" can be obtained from Carbide and Carbon Chemicals Corporation, 30 East 42nd Street, New York, N. Y.

• NEW HEADQUARTERS OF RICHARD HAWORTH

Shown above are two interior views of the new headquarters of Richard Haworth and at right an exterior view at the new location at 266 South Water St., Providence, R. I., as described in our issue of July 24.

• HERCULES RESEARCH ACTIVITIES

Hercules Powder Company recently announced the appointment of Dr. Emil Ott as director of research. With headquarters in Wilmington, Dr. Ott will be in charge of all company research. In this new position, he will work closely with those consuming industries which can utilize the facilities of the Hercules Experiment Station. Mr. O. A. Pickett continues as director of the Experiment Station.

Dr. Ott brings to his new position a scientific background, based on practical operating and teaching experience. He was born in Zurich, Switzerland, and graduated from the Swiss Institute of Technology in that city, specializing in chemistry, physics, and other branches of natural science.

Receiving his Ph.D. degree in 1927, Dr. Ott left Switzerland for America and after several years of practical chemical experience became assistant professor of chemistry at Johns-Hopkins University. He was engaged as consultant for Hercules Powder Company in April, 1933, and a few months later became a member of the company's development department. In 1937, he was appointed head of the research department at the Experiment Station.

• HYDRION BUFFER CAPSULES

A new series of reference standards, known as Hydrion Buffer Capsules, for checking electrometric pH apparatus is announced by Micro Essential Laboratory, Brooklyn, N. Y. Made up in the form of powder, carefully standardized and

packaged in capsules, this series of reference standards is said to offer various advantages to users of electrometric pH apparatus. This line is distributed by R. P. Cargille, 118 Liberty Street, New York.

• IMPERIAL RAYON CORP.

Stockholders of the New Process Rayon Corporation, at a meeting held recently at the plant of the company at Gloucester, N. J., ratified the change of name of the company to Imperial Rayon Corporation.

Directors elected for the company were Hudson W. Reed, Harry W. Harrison, P. E. Harrison, Standish F. Hansell, Halton A. Coward and Paul Zens.

Paul Zens continued as president and P. E. Harrison was named vice-president and general manager.

Controlling interest of the Imperial Rayon Corporation is held by Edward G. Budd Manufacturing Company, Philadelphia.

Mr. Zens said conditions in the industry had improved materially in recent months, and he expected production at the plant to be increased to 10,000 pounds of yarn daily.

The company employs a cuprammonium process for rayon production by which it can spin yarn in two and a half minutes, as compared with 36 hours required by the viscose process.

"An entirely new type of cuprammonium yarn has been developed by our laboratory," Mr. Zens added, "in which we obtain absolute color uniformity, high strength and elasticity. Dyeing of the rayon now is an integral part of the spinning process, enabling us to produce a variety of colors on a quantity basis."

Imperial Corporation also will specialize in yarns for cords used in automobile tires and in bleached and colored yarns for sewing thread.

The plant currently is operating at capacity, Mr. Zens reported at the meeting.

One of the company's new type machines is a part of the Budd Exhibit at the New York World's Fair.

• WARP SIZING PROJECT

W. D. Appel, chairman of the Research Council of the United States Institute for Textile Research, has announced the selection of the Textile School of North Carolina State College as the place for conducting the new research project on the warp sizing of spun rayon and cotton-spun rayon warps. Mr. Appel also announced the appointment of the following committee to administer the research project: Perrin N. Collier, vice-president and research director, Callaway Mills, chairman; Dr. W. E. Yelland, who was research director of the Institute's previous warp sizing research, and Dr. Thomas Nelson, Dean of the Textile School of North Carolina State College.

In order to facilitate the work of the Institute, the Textile School has purchased from the Cocker Machine & Foundry Company one of their newest rayon slashers and it will be installed in the new Textile building so that work on the research project can begin shortly after October first.

For a number of years the Textile School has cooperated with the Division of Cotton Markets of the United States Department of Agriculture in its endeavor to develop new uses for cotton products and now the research activities at the school are to be further expanded.

• APPOINTED CHIEF ENGINEER

Luke H. Sperry, former manager of the chemical cotton plant of Hercules Powder Company at Hopewell, Virginia, has been named chief engineer of the company, succeeding George E. Ramer, who retired August 1.

Mr. Sperry brings to his new position a wide variety of engineering and operating experience, gained in the Hercules organization. He completed his engineering studies at the University of Colorado in 1905. Then followed twelve years of engineering experience.

He joined Hercules Powder Company in 1918 as assistant superintendent of the dynamite plant at Hercules, California. In March, 1922, he was transferred to Emporium, Pennsylvania, as superintendent of that plant, and in October of the same year he was named superintendent of the dynamite plant at Kenvil, New Jersey. He was made manager of the chemical cotton plant at Hopewell, Virginia, November 1, 1928, and held that position until his present promotion.

• WATER-LUBRICATED PUMP

A new bulletin describing an improved type of water-lubricated pump has just been issued by the Peerless Pump Division of the Food Machinery Corporation. It is printed in three colors and shows an interesting cross-section of the entire pump assembly, revealing the flow of water through the bowls and the method of sealing the impellers by a double seal.

No oil is used below the surface in this type of pump and the entire shaft is supported by cutless fluted rubber bearings of exclusive Peerless design. The bearings are rigidly fixed in bronze spiders to eliminate gyration and vibration, according to the manufacturers. The bulletin describes the service of water-lubricated pumps in capacities ranging from a few gallons per minute to more than 10,000 g.p.m.

A copy of the bulletin may be obtained by addressing the company at 301 W. Ave. 26, Los Angeles.

• CLASSIFIED ADVERTISEMENTS •

POSITION WANTED: Dyer with 25 years' practical experience of dyeing of silk, rayon and acetate. Able to take full charge or supervise all operation of dyeing, laboratory praxis, expert in dyeing of fast colors. Best references, desires position as Dyer, Supervisor or Demonstrator. Will go anywhere. Write Box No. 199, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED: Young textile chemist. Graduate chemistry and dyeing department, Philadelphia Textile School, desires position in New York or New Jersey concern. Fine practical experience in the dyeing, finishing and printing of all fibers. Knowledge of cost, procedure and machinery involved. Specialties, backfilling and pile fabrics. Good references. Now employed. Salary secondary. Write Box No. 200, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED: Recent college graduate in textile chemistry and dyeing, honor student, scientific German, desires position in laboratory or plant in New York-New Jersey area. Write Box No. 201, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED: *Textile Chemist-Technologist.* M.I.T. 1932. Research and plant experience in dyeing, bleaching and mercerizing of cotton. Development work on textile finishes and auxiliary agents. Fiber and yarn research. Textile analyses and microscopy. Wool grease, lanolin and woolen mill waste treatment experience. Civil Service rating as Cotton Technologist. Former research associate A.A.T.C.C. Patents and publications. Desires responsible position. Write Box No. 202, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.